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Original Paper

The Impact of Information Technology on Patient Engagement and Health Behavior Change: A Systematic Review of the Literature

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Abstract

Background: Advancements in information technology (IT) and its increasingly ubiquitous nature expand the ability to engage patients in the health care process and motivate health behavior change.

Objective: Our aim was to systematically review the (1) impact of IT platforms used to promote patients' engagement and to effect change in health behaviors and health outcomes, (2) behavior theories or models applied as bases for developing these interventions and their impact on health outcomes, (3) different ways of measuring health outcomes, (4) usability, feasibility, and acceptability of these technologies among patients, and (5) challenges and research directions for implementing IT platforms to meaningfully impact patient engagement and health outcomes.

Methods: PubMed, Web of Science, PsycINFO, and Google Scholar were searched for studies published from 2000 to December 2014. Two reviewers assessed the quality of the included papers, and potentially relevant studies were retrieved and assessed for eligibility based on predetermined inclusion criteria.

Results: A total of 170 articles met the inclusion criteria and were reviewed in detail. Overall, 88.8% (151/170) of studies showed positive impact on patient behavior and 82.9% (141/170) reported high levels of improvement in patient engagement. Only 47.1% (80/170) referenced specific behavior theories and only 33.5% (57/170) assessed the usability of IT platforms. The majority of studies used indirect ways to measure health outcomes (65.9%, 112/170).

Conclusions: In general, the review has shown that IT platforms can enhance patient engagement and improve health outcomes. Few studies addressed usability of these interventions, and the reason for not using specific behavior theories remains unclear. Further research is needed to clarify these important questions. In addition, an assessment of these types of interventions should be conducted based on a common framework using a large variety of measurements; these measurements should include those related to motivation for health behavior change, long-standing adherence, expenditure, satisfaction, and health outcomes.

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KEYWORDS

patient engagement; patient behavior; technology; Internet; web-based; cell phone; social media

Introduction

Patient engagement is currently considered the cornerstone of the health care system revolution for its positive impact on health outcomes and health care costs [1,2]. A growing body of evidence demonstrates that lack of patient engagement is a major contributor to preventable deaths. In fact, it is estimated that 40% of deaths in the United States are caused by modifiable behavioral issues, including smoking, obesity, poor blood sugar control, poor blood pressure control, inadequate exercise, medication non-adherence, and neglect in attending follow-up medical appointments [3]. As a result, patients must be encouraged to become more involved with managing their own care. Frequent, real-time communication and feedback are essential in supporting health behavior change and empowering patient engagement in the health care process [4]. However, the traditional model of care delivery, a face-to-face interaction with an expert or trusted health care provider, can be implemented only with a small number of patients and thus has limited impact and limited reach [5]. In an effort to reach and engage larger numbers of patients, researchers and clinicians have begun exploring the role of information technology (IT) platforms in patient engagement and health behavior change interventions [5,6]. It is assumed that face-to face interaction in the traditional model can be mimicked by peer-to-peer or peer group support in social media.

IT platforms are being embraced as a way to enhance patient engagement in the health care process, improve quality of care, support health care safety, and provide cost-effective health services for patients [6-9]. Numerous IT platforms are used to motivate patient engagement in health behavior change including short message service (SMS)-capable mobile devices, Internet-based interventions, social media, and other online communication tools [10-12]. Previous systematic reviews have evaluated the potential benefit of IT platforms in managing different health conditions and how these platforms have been used to actively engage patients and change unhealthy patient behavior. A systematic review conducted to assess the effectiveness of IT platforms on physical activity and dietary behavior change found that 51% of studies showed positive results, although a significant proportion of the studies showed no significant effect [13]. The reviewed interventions tended to focus on specific technology (eg, desktop applications), while mobile devices, such as mobile phones and text messaging devices were not included. Similarly, Webb et al reviewed 85 studies on the impact of Internet-based interventions on health behavior change and found small but significant effects on health-related behavior, especially with regards to interventions grounded in behavioral theory. Although the review mentioned that the effectiveness of Internet-based interventions was enhanced by using additional IT methods, such as text messaging (SMS), it did not focus on the distinction between these different interventions [8].

In addition, a meta-analysis performed to investigate the effectiveness of Web-based interventions on health behavior changes found that Web-based interventions improve patient outcomes. This particular meta-analysis, however, referred only to Web-based interventions in specific problem areas and focused on a relatively narrow range of technologies [14]. A recent systematic review that investigated the effectiveness of the IT platform on self-management among diabetic patients showed positive effects in 74% of studies [15]. Another research study showed that successful health behavior interventions may contribute to understanding of health behavior theories and their appropriate use [16]. Mobile-based interventions and Web-based interventions developed based on health behavior theories are more likely to effectively change patient health behavior and maintain behavior change than non-theory-based interventions [8,17-19]. Basing IT interventions on behavior theories can help test and detect why interventions succeed or fail [20]. Health behavioral theories can identify key determinants of the target behaviors and identify behavior change strategies essential to obtain desired health outcomes; this knowledge can then be transformed into specific behavioral strategies that patients can adapt in their daily life [20].

Conclusions drawn from these reviews are important; they provide insights but no clear answers about the effectiveness of IT platforms on patient engagement and behavior change. They do not address which interventions are used most or are most effective with which theory or model when it comes to improving patients' health behaviors and patient engagement. IT platforms generally can have high potential benefits and some proven effects; however, specific components in several health conditions associated with success remain unclear. To better understand how to build a successful intervention that can engage patients to change their behavior meaningfully, we performed a systematic review.

Review aims were to systematically determine (1) the impact of IT platforms used to promote patient engagement and to effect change in health behaviors and health outcomes, (2) behavioral theories or models applied as bases for developing these interventions and their impact on health outcomes, (3) different ways of measuring health outcomes, (4) usability, feasibility, and acceptability of these technologies among patients, and (5) challenges and research directions for implementing IT platforms to meaningfully impact patient engagement and health outcomes.

Methods

Search Strategy and Data Sources

Electronic literature searches were performed using four databases: PubMed, Web of Science, PsycINFO, and Google Scholar. Google Scholar was searched because it had sufficiently wide coverage to be used instead of several databases [21-23]. The reference lists of retrieved articles from searches were screened for additional articles. Searches used the following medical subject headings (MeSH) terms in various combinations: patient engagement, health, promotion, behavior, digital, technology, email, Internet, Web-based, cell phone, social media, computer, and intervention.

Inclusion and Excluding Criteria

The following criteria were used to select the articles: (1) all types of study designs published in scientific journals between 2000 and December 2014 were included, excluding conference

proceedings, book chapters, reviews, dissertations, and protocols. (2) studies that evaluated and reported the impact of health information technology platforms on patients' health outcome, (3) studies that focused on disease management rather than more general health promotion including but not limited to patient education, symptom monitoring, medication adherence, diet, and physical activity, (4) studies that addressed patient engagement and health-related behavior change through the use of IT platforms such as social networking sites, mobile telephony, video and teleconferencing, email, SMS, and electronic monitoring, (5) studies that explored different factors affecting patient engagement and health behavior change were excluded, (6) studies that were published in languages other than English were excluded, (7) studies where the patient was not the main actor (ie, studies that were clinician-focused), and (8) the methodological quality (see Multimedia Appendix 1) of articles was evaluated to establish their inclusion in the review using 10 items adopted from Critical Appraisal Skills Programme (CASP) [24,25]. The criteria that were used in the quality assessment included (1) study name, (2) aims clearly stated, (3) appropriate research design, (4) appropriate recruitment strategy, (5) theories clearly stated, (6) usability tested within the study, (7) patient engagement part of study, (8) appropriate data collection method, (9) data analysis sufficiently rigorous, and (10) findings clearly stated. After the completion of the methodological quality assessment, the studies that met the criteria for the categories of "good" were reviewed (ie, bad=0-33%, satisfactory=34-66%, and good=67-100%) [26].

Data Extraction

Two investigators independently reviewed the titles and then abstracts. The same investigators read and screened for full text eligibility. Data extraction was carried out by 1 reviewer and was rechecked for accuracy by another reviewer. The reasons for exclusion were recorded. Discrepancies were resolved by joint probability of agreement (0.98) [15].

A meta-analysis was not feasible due to the varying data collection methods and outcome measures. Therefore, eligible studies were broken down and evaluated in a narrative format using some statistical analysis when feasible and summarized systematically according to the following key information abstracted from them: study details (including author name, year, country, and study design); study characteristics (including sample size and condition/disease); intervention details (including technology used and duration); and outcome details (including direct and indirect assessment methods); and impact of intervention, usability assessment, patient engagement, and theory used in interventions classified according to Leventhal (biomedical model, behavioral learning, communicative, cognitive theory, and self-regulative) [27-29].

The outcomes variable was classified into (1) positive impact in which health information technology platform was associated with improvement in one or more aspects of care and (2) no impact or no noticeable improvement or change in health outcomes. This was assessed based on the overall conclusion made by the authors of each study. Most studies used statistical methods to test hypotheses or describe quantitative findings.

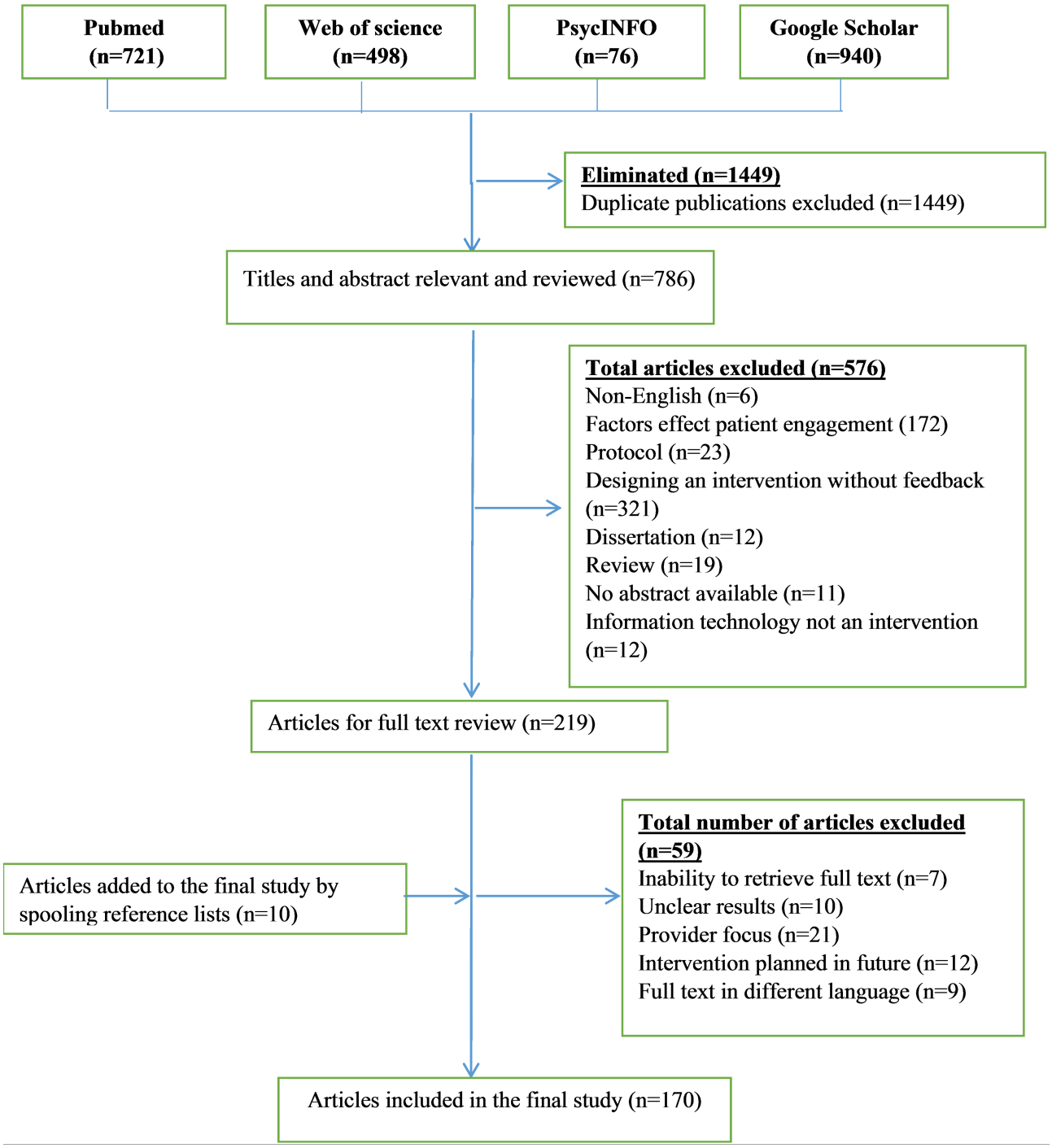
Patient engagement was measured based on the overall conclusion. This was usually measured by timed patient log-ins, communication with the health care provider via secure message, or data download.

Results

Search and Selection Results

Figure 1 shows the flow chart that describes the process of identifying the relevant literature. A separate comprehensive search using 4 databases yielded 2235 articles. Following removal of duplicates, our search identified 786 potentially relevant articles. These were scanned keeping 219 papers for full reading at full text level, of which 59 were screened and rejected, leaving 160 studies to be included in the review. Ten additional papers were included from the reference lists of retrieved articles. A total of 170 articles matched the initial search criteria.

Figure 1. Flow diagram of included and excluded studies.



Article Characteristics

Table 1 provides a summary of the studies, and Multimedia Appendix 2 summarizes the 170 articles included in the research study and their characteristics. Multimedia Appendix 1 summarizes the quality assessment of the 170 included articles. Multimedia Appendix 3 contains definitions of terms used in the paper. Different categories of IT platforms were identified including Internet-based interventions (50.6%, 86/170), mobile-based interventions (25.9%, 44/170), social media (9.4%, 16/170), video game technology (3.5%, 6/170), and telemonitoring (10.6%, 18/170). Publication years ranged from 2000 to 2014, with an overall increase in articles published more recently (21.8%, 37/170 in 2014). The majority of studies were implemented in the United States (54.7%, 93/170). With respect to the different targeted disorders, hormonal disorders were most frequently targeted (22.4%, 38/170 studies, eg, diabetes). The literature was dominated by randomized controlled trials (65.9%, 112/170). The duration of these studies ranged from 1 week to 48 months, and sample sizes ranged from 1-22,337 subjects. Articles included in this review were categorized in five topics based on study aims: impact of IT platform on health outcomes, patient engagement in health behavior change, theory of health behavior, ways to assess health outcomes, and usability assessment (see Table 1).

Table 1. Summary of the review results based on types of IT platforms.

		Internet (N=86)	Phone (N=44)	Video game (N=6)	Social network (N=16)	Tele-monitoring (N=18)
Health condition, n (%)						
	Bone, joint, and muscle disorders	3 (3)				
	Brain, spinal cord, and nerve disorders	7 (8)	1 (2)	2 (33)	1 (6)	1 (6)
	Cancer	5 (8)	2 (5)	1 (17)	2 (13)	2 (11)
	Disorders of nutrition and metabolism	13 (15)	4 (9)	1 (17)	2 (13)	1 (6)
	Ears, nose, and throat disorders		1 (2)			
	Eye disorders					1 (6)
	Health hazard	5 (6)	6 (14)			
	Heart and blood vessel disorders	5 (6)	3 (7)			6 (33)
	Hormonal disorders	20 (23)	11 (25)		4 (25)	3 (17)
	Immune disorders	4 (5)	5 (11)		1 (6)	1 (6)
	Lung and airway disorders	2 (2)	1 (2)	1 (17)	1 (6)	1 (6)
	Mental health disorders	12 (14)	4 (9)	1 (17)	2 (13)	2 (11)
	Skin disorders		1 (2)		1 (6)	
	Women's health issues	3 (3)	1 (2)			
	Not specified	7 (8)	4 (9)		2 (13)	
Country, n (%)						
	Australia	7 (8)	5 (42)			
	Austria					1 (6)
	Bangladesh		1 (2)			
	Canada	4 (5)				2 (11)
	Chile	1 (1)				
	China		1 (2)			
	France		1 (2)			
	Germany	3 (3)				
	Israel				1 (6)	
	Italy	1 (1)	1 (2)			
	Japan	1 (1)			1 (6)	
	Kenya		1 (2)			
	Korea	1 (1)	1 (2)			1 (6)
	Malaysia		1 (2)			
	Netherlands	4 (5)		1 (17)		2 (11)
	New Zealand		2 (5)			
	Norway		1 (2)			
	Poland					1 (6)

		Internet (N=86)	Phone (N=44)	Video game (N=6)	Social network (N=16)	Tele-monitoring (N=18)
	Russia		1 (2)			
	Slovenia	1 (1)				
	South Korea	2 (2)	4 (5)			
	Spain		1 (2)			1 (6)
	Sweden	2 (2)				
	Switzerland					1 (6)
	Taiwan	1 (1)				
	United Kingdom	5 (6)	7 (16)	1 (17)		1 (6)
	United States	53 (62)	14 (32)	4 (67)	14 (88)	8 (44)
	Victoria		1 (2)			
	Vietnam		1 (2)			
Study design, n (%)						
	Randomized controlled trial	55 (64)	34 (30)	2 (33)	7 (44)	14 (78)
	Case study	2 (2)	1 (2)	2 (33)	2 (13)	
	Cohort study	10 (12)	4 (5)	1 (17)	1 (6)	3 (17)
	Cross-sectional analysis	8 (9)	1 (2)		5 (31)	1 (6)
	Quasi-experimental trial	11 (13)	4 (5)	1 (17)	1 (6)	
Ways to measure health outcomes, n (%)						
	Direct	28 (33)	20 (45)	3 (50)	1 (6)	6 (33)
	Indirect	58 (67)	24 (55)	3 (50)	15 (94)	12 (67)
Impact of technology, n (%)						
	Yes	75 (87)	41 (93)	6 (100)	13 (81)	16 (89)
	No	11 (13)	3 (7)		3 (19)	2 (11)
Usability assessment, n (%)						
	Yes	38 (44)	8 (18)	1 (17)	8 (50)	3 (17)
	No	48 (56)	36 (82)	5 (83)	8 (50)	15 (83)
Patient engagement, n (%)						
	Yes	68 (79)	38 (86)	6 (100)	13 (81)	16 (89)
	No	18 (21)	6 (14)		3 (19)	2 (11)
Theory of behavior change, n (%)						
	Biomedical theory (chronic model)	1 (1)				1 (6)
	Behavioral learning theory	3 (3)				
	Communication (social support theory)	5 (6)	5 (11)		2 (13)	
	Cognitive theory[a] (TPB, SOC, TTM, self-efficacy, information motivation, and behavioral skill)	40 (47)	9 (20)	2 (33)	2 (13)	1 (6)

		Internet (N=86)	Phone (N=44)	Video game (N=6)	Social network (N=16)	Tele-monitoring (N=18)
	Self-regulatory	6 (7)		1 (17)	2 (13)	
	Not specified	31 (36)	30 (69)	3 (33)	10 (63)	16 (88)
Sample size, n						
	Min.	1	2	6	51	10
	Max.	13564	22337	375	1754	784
Duration						
	Min.	1 mo	1 mo	1 mo	1 wk	2 mo
	Max.	48 mo	16 mo	3 mo	36 mo	39 mo
	Not specified	3	1	1	3	1

[a]TPB= theory of planned behavior, SOC=stage of change, TTM= transtheoretical model.

Impact of IT Platforms on Health Outcomes

Overall, IT platforms have been shown to improve health behavior among different disease categories (88.8%, 151/170), although the majority of the positive impact has been shown among hormonal disorders (20.6%, 35/170) (see Table 2). Among studies utilizing Internet-based platforms, 87% (75/86) of studies showed a significant impact on health outcomes. Studies also showed that the use of Internet-based tailored weight control programs was correlated with significant increases in weight loss [30,31] and walking distance (P<.05) [32]. Similarly, mobile-based platforms showed significant effects on health outcomes (91%, 40/44). For example, a study examined use of text messages among patients with diabetes and found a significant decrease in HbA1C level, improved medication adherence, and decreased in emergency service use [33]. Social media showed a positive impact on health outcomes (81%, 13/16). For example, one study indicated that Twitter usage among cancer patients was a valuable medium for sharing information, discussing treatments, and also acted as a psychological support [34]. The use of Facebook has also been found to help improve asthma care [35]. As such, this review found that 100% (6/6) of studies had a positive impact on patient health behavior when implementing a video game as an intervention to change health behavior. In a specific example, King et al concluded that video games can be implemented successfully among hyperfunctional voice disorder as a “voice therapeutic protocol”, a voice and speech therapy program including a set of vocal tasks using syllable repetitions and chanting of songs and phrases [36]. Furthermore, the literature showed that telemonitoring improved health outcomes (89%, 16/18). One telemonitoring-based study assessed the effects of a glucose monitoring system on HbA1c levels in diabetic patients and found that usage of this system was correlated with a significant decrease in HbA1c (P=.001) [37]. Another study evaluated the impact of home-based telemonitoring on patients with heart failure and showed a significant correlative improvement in patients’ health outcomes [38,39].

In contrast, 11% of studies (19/170) showed no impact of using IT platforms on health behavior. Among studies using Internet-based platforms, 13% (11/86) did not find significant results. One study using a Web-based behavior change program found no differences in smoking abstinence rates at 3- and 6-month follow-up assessment [40] and no maintenance of weight loss in an Internet-based intervention group compared to the study’s control group [41]. Also, 7% of (3/44) mobile phone studies reported non-significant impact [33,42-44]. Two mobile phone platform studies did not find a significant reduction in HbA1c level among diabetic patients when SMS text messaging was used to manage their health care (P<.10) [33,34]. Moreover, 18% (3/16) of studies showed undesirable effects from using social media [35,45,46]. For instance, Kaplan et al found that psychiatric patients who participated in Internet peer support reported higher levels of distress compared to those who did not participate [45]. The literature shows that 12% (2/18) of telemonitoring studies had no effect on health outcomes. One particular study found significant changes in neither readmission rate [47] nor medication adherence [48] among patients with heart failure.

Table 2. Impact of IT platforms among different disorders (Yes=positive impact, No=no impact).

Disorders	Impact of IT platforms, n (%)											
	Internet		Mobile		Social media		Tele-monitoring		Video game			
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Total yes	Total no	Total
Bone, joint, and muscle	3 (3)									3 (2)		3 (2)
Brain, spinal cord, and nerves	7 (8)		1 (2)			1 (6)	1 (6)		2 (33)	11 (6)	1 (1)	12 (7)
Cancer	5 (6)		2 (5)		2 (13)		2 (11)		1 (17)	12 (7)		12 (7)
Nutrition and metabolism	10 (12)	3 (3)	4 (9)		2 (13)		1 (6)		1 (17)	18 (11)	3 (3)	21 (12)
Ears, nose, and throat				1 (2)							1 (1)	1 (1)
Eye							1 (6)			1 (1)		1 (1)
Health hazard	4 (5)	1 (1)	6 (14)							10 (6)	1 (1)	11 (6)
Heart and blood vessel	4 (5)	1 (1)	3 (7)				4 (22)	2 (11)		11 (6)	3 (2)	14 (8)
Hormonal	19 (22)	1 (1)	9 (20)	2 (5)	4 (25)		3 (17)			35 (21)	3 (2)	38 (22)
Immune system	2 (2)	2 (2)	5 (11)			1 (6)	1 (6)			8 (5)	3 (2)	11 (6)
Lung and airway	2 (2)		1 (2)		1 (6)		1 (6)		1 (17)	6 (4)		6 (4)
Mental health	11 (13)	1 (1)	4 (9)		2 (13)		2 (11)		1 (17)	20 (12)	1 (1)	21 (12)
Not specified	5 (6)	2 (2)	4 (9)		1 (6)	1 (6)				10 (6)	3 (2)	13 (8)
Skin			1 (2)		1 (6)					2 (1)		2 (1)
Women's health	3 (3)		1 (2)							4 (2)		4 (2)
Total	75 (87)	11 (13)	41 (93)	3 (7)	13 (81)	3 (19)	16 (89)	2 (11)	6 (100)	151 (89)	19 (11)	170 (100)

Patient Engagement

In total, 82.9% (141/170) of studies reported improvement in patient engagement after using IT platforms (see Table 3). Among Internet-based interventions, 79% (68/86) of studies reported a high level of patient engagement. For example, a research study reported that human immunodeficiency virus patients used the Internet-based intervention a majority of the time to access information and manage their health [49,50]. Among studies using mobile-based interventions, 86% (38/44) reported improvement in patient engagement. One mobile-based intervention study found that text messaging enhanced successful engagement of diabetic patients in their own health care. Patients were able to use this study's text message system for clinical data queries and communicating with health care providers [51]. Similarly, 81% (13/16) of studies reported that social media was helpful in improving patient engagement. One study found that Facebook provided a forum for reporting personal experiences, asking questions, and receiving direct feedback for people living with diabetes [46]. Another study showed that social media was helpful to individuals with lower patient activation [52-54]. In addition, it was found that video games could enhance patients' active participation in the health care process (100%, 6/6). One video game-based study demonstrated that a health-based video game could help build an effective client-therapist relationship, help structure sessions, and improve patient engagement in the therapeutic process [55,56]. Likewise, the literature showed that telemonitoring has been particularly useful for improving patient engagement remotely (88.8%, 16/18) [57-63], as traditional point-of-care-based ways to monitor patients are costly and difficult to implement [64].

Overall, analysis showed significant correlations between patient engagement in health care and the impact of IT platforms (χ^2_1=39.8836, P<.001). Only Internet-based platforms had a significant association between patient engagement and impact of technology on outcomes (χ^2_1=28.2558, P<.001).

Table 3. Impact of IT platforms on patient engagement (Yes=positive impact, No=no impact).

Engagement	Impact of IT platforms, n (%)											
	Internet		Mobile		Social media		Tele-monitoring		Video game	Total yes	Total no	Total
	Yes	No	Yes	No	Yes	No	Yes	No	Yes			
Yes	66 (88)	2 (18)	36 (88)	2 (67)	12 (92)	1 (33)	15 (94)	1 (50)	6 (100)	135 (63)	6 (32)	141 (83)
No	9 (12)	9 (82)	5 (12)	1 (33)	1 (8)	2 (67)	1 (6)	1 (50)		16 (37)	13 (68)	29 (17)
Total	75 (100)	11 (100)	41 (100)	3 (100)	13 (100)	3 (100)	16 (100)	2 (100)	6 (100)	151 (100)	19 (100)	170 (100)

Behavior Theory

Overall results showed that 47.0% (80/170) of the literature explicitly referenced theory (see Table 4). Among Internet-based interventions, 64% (55/86) of studies mentioned the use of behavior theories. Cognitive theories dominated this category (47%, 40/86). Further, 32% (14/44) of mobile-based intervention studies reported use of behavior theories. Cognitive theories were also the most widely used among this category (30%, 13/44) [42,51,65-71]. Moreover, 38% (6/16) of social media studies used behavior change theory. Social support, cognitive, and self-regulatory theories were the only models used in this category [35,45,52,72-74]. The analysis showed 50% (3/6) of video-game platforms used behavior change theories, where the cognitive and self-regulatory theories are the only used [75,76]. Only 11% (2/18) of telemonitoring studies used biomedical and cognitive theories [77,78]. Literature showed that 89% (71/80) of studies with behavior theories had a significant impact on health outcomes. Only 11% (9/80) of telemonitoring studies explicitly referenced the use of behavior theories and showed no impact of technology on health outcomes. The result failed to show any relationship between using behavior theory and the impact of technology on health outcomes (χ^2_1=0.008, *P*=.977).

The analysis also found no significant correlative relationship between behavior theory and patient engagement in health care (χ^2_1=0.3055, *P*=.580479). However, there was a significant relationship between patient engagement and Internet-based interventions using behavior theories (χ^2_1=7.3144, *P*=.00684) (see Table 5).

Table 4. Impact of IT platforms and theories of health behavior (Yes=positive impact, No=no impact).

Behavior theory	Impact of IT platforms, n (%)											
	Internet		Mobile		Social media		Tele-monitoring		Video game			
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Total yes	Total no	Total
Biomedical theory (chronic model)	1 (1)						1 (6)			2 (1)		2 (1)
Behavioral learning theory	2 (2)	1 (1)								2 (1)	1 (1)	3 (2)
Communication (social support theory)	4 (5)	1 (1)	1 (2)		1 (6)	1 (6)				6 (4)	2 (1)	8 (5)
Cognitive theory (TPB, SOC, TTM, self-efficacy, information motivation, and behavioral skill)	36 (42)	4 (5)	12 (27)	1 (2)	2 (13)		1 (6)		2 (33)	53 (31)	5 (3)	58 (34)
Self-regulatory	5 (6)	1 (1)			2 (13)				1 (17)	8 (5)	1 (1)	9 (5)
Total of used theory	48 (56)	7 (8)	13 (29)	1 (2)	5 (31)	1 (6)	2 (2)		3 (50)	71 (42)	9 (5)	80 (47)
Theory not reported	27 (31)	4 (5)	28 (64)	2 (5)	8 (50)	2 (13)	14 (78)	2 (11)	3 (50)	80 (47)	10 (6)	90 (53)
Total	75 (87)	11 (13)	41 (93)	3 (7)	13 (81)	3 (19)	16 (89)	2 (11)	6 (100)	151 (89)	19 (11)	170 (100)

Table 5. Patient engagement and theories of health behavior (Yes=positive impact, No=no impact).

Behavior theory	Patient engagement, n (%)											
	Internet		Mobile		Social media		Tele-monitoring		Video game			
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Total yes	Total no	Total
Biomedical theory (chronic model)	1 (1)						1 (6)			2 (1)		2 (1)
Behavioral learning theory	2 (2)	1 (1)								2 (1)	1 (1)	3 (2)
Communication (social support theory)	5 (6)		1 (2)		2 (13)					8 (5)		8 (5)
Cognitive theory (TPB, SOC, TTM, self-efficacy, information motivation, and behavioral skill)	30 (35)	10 (12)	11 (25)	2 (5)	2 (13)		1 (6)		2 (33)	46 (27)	12 (7)	58 (34)
Self-regulatory	4 (5)	2 (2)			2 (13)				1 (17)	7 (4)	2 (1)	9 (5)
Total of used theory	42 (49)	13 (12)	12 (27)	2 (5)	6 (38)		2 (11)		3 (50)	65 (38)	15 (9)	80 (47)
Theory not reported	26 (30)	5 (2)	26 (59)	4 (9)	7 (44)	3 (19)	16 (89)	2 (11)	3 (50)	76 (45)	14 (8)	90 (53)
Grand Total	68 (79)	18 (15)	38 (86)	6 (14)	13 (81)	3 (19)		2 (11)	6 (100)	141 (83)	29 (17)	170 (100)

Methods to Measure Health Outcomes

Most studies used indirect ways (such as self-reports) to measure health outcomes (65.9%, 112/170). The literature showed that 57.6% (98/170) of studies showed a positive impact of IT platforms when the health outcomes were assessed using indirect ways. For example, self-reporting was used to assess whether a text message could increase smoking cessation [68], reduce methamphetamine use among human immunodeficiency virus patients [79], and to assess medication adherence among patients with congestive heart failure [48]. The analysis showed no significant association between ways to measure health outcomes and technology impact (χ^2_1=0.5793, *P*=.446603) (see Table 6).

Table 6. Impact of IT platforms and methods to measure health outcomes (Yes=positive impact, No=no impact).

Methods to measure health outcomes	Impact of information technology platforms, n (%)											
	Internet		Mobile		Social media		Tele-monitoring		Video game			
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Total yes	Total no	Total
Direct	25 (29)	3 (3)	18 (41)	2 (5)	1 (6)		6 (33)		3 (50)	53 (31)	5 (3)	58 (34)
Indirect	50 (58)	8 (9)	23 (52)	1 (2)	12 (75)	3 (19)	10 (56)	2 (11)	3 (50)	98 (58)	14 (8)	112 (66)
Grand Total	75 (87)	11 (13)	41 (93)	3 (7)	13 (81)	3 (19)	16 (89)	2 (11)	6 (100)	151 (89)	19 (11)	170 (100)

Usability Assessment

Only 33.5% (57/170) of studies assessed the usability of IT platforms. Of those, the majority were considered by authors to be usable (89%, 51/57). Specifically, 75% (28/37) of Internet-based IT intervention studies showed positive health outcomes with usable interventions [41,80-106]. In one study that gauged usability, Steele et al performed a 3-month randomized controlled trial among 192 participants and found an Internet-based physical activity behavior change program to be usable, feasible, and acceptable among inactive participants [41]. Mobile-based interventions also showed 75% (6/8) of usable interventions had a positive impact on health outcomes [42,69,93,107-109]. In one study, SMS was found to be useful in helping patients to remember to take their medications and be engaged in treatment planning [107]. SMS-based intervention was also found to be useful in promoting communication with health care providers by delivering, receiving health information, generating questions, and seeking information related to health conditions [42]. Moreover, 87% (7/8) of studies reported that the usability of social media-based interventions was positively correlated with good impact on health outcomes [34,35,46,52,53,110,111]. One particular social networking-related study found that online health-related social networking was useful and acceptable in chronic disease management [52]. In addition, one study reported the usability assessment in the video-game category and found that it was usable and had a positive impact among patients with hyperfunctional voice disorders [36]. Overall, the analysis also found that telemonitoring also showed similar results (100%, 3/3). One telemonitoring-based study found that

telecommunication-based reminder tools are useful for improving medication adherence [112].

Although our results failed to report any relationship between usability of IT platforms and the impact on health outcomes (P=.1065), they showed significant association between usability and patient engagement in health care (P=.0216) (Fisher's exact test) (see Tables 7 and 8).

Table 7. Impact of IT platforms and usability (Yes=positive impact, No=no impact).

Usability	Impact of information technology platforms, n (%)											
	Internet		Mobile		Social media		Tele-monitoring		Video game			
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Total yes	Total no	Total
Usable	28 (33)	4 (5)	6 (14)	2 (5)	5 (31)	2 (13)	3 (17)		1 (17)	43 (25)	8 (5)	51 (30)
Not usable	1 (1)	4 (5)			1 (6)					4 (2)	2 (1)	6 (4)
Total of assessed usability	29 (34)	8 (9)	6 (14)	2 (5)	6 (38)	2 (13)	3 (17)		1 (17)	12 (7)	45 (26)	57 (34)
Not assessed usability	46 (53)	3 (3)	35 (80)	1 (2)	7 (44)	1 (6)	13 (72)	2 (11)	5 (83)	7 (4)	106 (62)	113 (66)
Grand total	75 (87)	11 (13)	41 (93)	3 (7)	13 (81)	3 (19)	16 (89)	2 (11)	6 (100)	19 (11)	151 (89)	170 (100)

Table 8. Patient engagement and usability (Yes=positive impact, No=no impact).

Usability	Impact of information technology platforms, n (%)											
	Internet		Mobile		Social media		Tele-monitoring		Video game			
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	Total yes	Total no	Total
Usability assessed (usable)	26 (30)	6 (7)	7 (16)	1 (2)	5 (31)	2 (13)	3 (17)		1 (17)	41 (24)	9 (5)	51 (30)
Usability assessed (not usable)	1 (1)	4 (5)			1 (6)					2 (1)	4 (2)	6 (4)
Total usability assessed	27 (31)	10 (12)	7 (16)	1 (2)	6 (38)	2 (13)	3 (17)		1 (17)	43 (25)	13 (8)	57 (34)
Not assessed	41 (48)	8 (9)	31 (70)	5 (11)	7 (44)	1 (6)	13 (72)	2 (11)	5 (83)	97 (57)	16 (9)	113 (66)
Grand total	68 (79)	18 (21)	38 (86)	6 (14)	13 (81)	3 (19)	16 (89)	2 (11)	6 (100)	141 (83)	29 (17)	170 (100)

Discussion

Principal Findings

Impact of IT Platforms on Health Outcomes

Overall, this review indicated that IT platform-based health interventions had a great impact on patients' health outcomes in the United States and in other nations. IT-based health interventions have been viewed as driving positive health behavior change through patient engagement with most technology platforms. IT-based health interventions also provide necessary information and advice and counseling related to certain diseases and conditions, such as mental disorders [113-120], asthma [57,76,96,121-123], obesity [30,32,124-132], smoking [40,68,69,88,133-136], diabetes [11,137-151], sleep disorder [152], hypertension [127,153,154], cancer [34,58,60,74,75,82,92,97,98,155-157], thereby encouraging healthy living [30,31,72,124,158,159]. Moreover, these interventions enable patients to be engaged in self-monitoring, thereby directing patients toward healthy eating, enhancing attendance rate [136,160-166], improving medication adherence [162,167-173], increasing knowledge about disease and treatment [33,42,47,75,85,90,94,96,115,119,168,174,175], and enhancing exercise use [32,56,80-82,122,125,126,128-132,153,156,176-183]. Online coaching by specialists enables patients to recover quickly, ensuring that the pain they experience is reduced [89,184], and doctor-patient communications are made readily available [73,157,185-191].

Apart from Internet-based technologies, mobile phone technologies have been used extensively to engage patients and ensure there is patient health behavior change. Mobile phone technologies engage patients by using SMS to contact them and provide necessary health information. This technology can be very effective and efficient, since it is less expensive and therefore more people can afford it. Studies have shown that patients can receive health-related information, receive reminders of their health care attendance, as well as be encouraged to adhere to their treatment [35,77-67,107,192].

Social media outlets, such as Twitter and Facebook, can ensure patients get and exchange necessary health information [34,46]. Video game and telemonitoring technologies served a similar purpose; these technologies tried to engage patients in order to provide necessary health information and provided a platform for helping patients adhere to treatment and helped patients

actively become involved in the treatment process. These technologies are of great importance to patients as well as helpful to health care providers, therefore ensuring effectiveness and efficiency.

Although several studies demonstrated the positive impact of IT platform usage, others showed no impact [33,35,41,43,45-48,81,83,91,133,141,178,193-198]. This could be due to the timing of the follow-up assessments ranging from one extremely short follow-up timing (1 week) to a relatively long-term follow-up timing (48 months). The lack of consistency in follow-up timing made it unclear as to how long these effects on patient health last. Moreover, the technology adoption rate may decline after a certain time period, thus diminishing its effectiveness after significant results at the beginning of the study. This occurred in a study by Williamson et al who found that after 2 years of an IT-based intervention, the decrease in body weight did not differ between the intervention and control group [28]. Similarly, another research study found a slow decline in HbA1c at 3 months follow-up (1.22%) versus (1.09%) 6 months follow-up [199,137]. Therefore, designing and evaluating IT platforms may become a significant challenge because researchers are dealing with a large volume of interventions that have different impacts on patient health behavior. Thus, several issues need to be addressed if such interventions are to be evaluated or assessed, such as length of intervention, type of technology, usability of the technology, application of behavior theory, and how health outcomes are measured.

Patient Engagement in Health Care Using IT Platforms

Our review showed that IT platforms are playing a significant role in patient engagement. This review implies that higher patient participation in condition self-management was correlated with greater improvement in health outcomes. Many studies have shown that patients who actively participated in health care experience better health outcomes compared to less involved patients. One specific study showed a significant association between patient engagement using the Internet and weight loss at 6 months (P<.001) [77]. Another study reported that a text messaging-based intervention could enhance patient engagement [33]. Social networks can also be particularly helpful to individuals with lower patient activation [52]. Despite the evidence regarding the importance of patient engagement, it is challenging to draw solid conclusions. Many of the studies conducted qualitative surveys to measure patient engagement or relied solely on the number of times patients logged in or uploaded data to determine their engagement. However, system log-ins and upload and download data are not engagement. Patient engagement is basically about interaction and participation in managing one's health to achieve desired goals. Therefore, further research is needed to determine the best ways to measure patient engagement.

Association Between Usability of IT Platforms and Their Impact

Our review found limited levels of evidence supporting the correlation between usability and impact of technology on health outcomes (P=.1065). Several factors may hinder the positive impact of technology on health outcomes other than usability issues. Patients' willingness to participate in managing their health care could be one of the main reasons. The review found a significant relationship with patient engagement and impact of technology. It found also a significant positive correlation between patient engagement and usability of IT platforms. Even though the aim of this study was not to discover determinants of patient engagement, several issues were identified including unequal access to technology, technical issues, poor interface design, suboptimal message content, privacy and confidentiality issues [46,108,110,121,165,193,200], and patients' self-perceived health illiteracy. The latter issue was seen in social media, where patients think such a discussion should be restricted to health care professionals [46]. Also, the majority of technologies rely on patient-provider engagement from both sides to exchange information and manage health conditions, such as in two-way SMS, thus increasing burden on providers as well as patients. Moreover, in some countries like Sweden, information dissemination can be restricted by legal and ethical regulations for online patient-provider communication [201]. Therefore, more research on the usability and acceptability of these technologies and discovering the different factors that impact patient engagement and their meaningful use will be required in the future.

Association Between Technology Impact and Intervention Grounded in Behavior Change Theories

This review found that only a limited number of specific behavioral theories and models were referenced among multiple articles inferring a theoretical design. This could imply that several IT interventions are designed in an ad hoc way, without using any theoretical frameworks. This finding supports the results of a previous study showing the majority of mobile-based interventions used for improving medication adherence and disease management were developed without a theoretical basis [202]. The review failed to detect any relationship between (1) behavioral theories and impact of technology or (2) theories and patient engagement. This could imply that existing theories/model were not developed to be used with these technologies. We found a significant association between patient engagement in Internet-based interventions and use of behavior theories in these interventions (χ^2_1=7.3144, P=.00684). This could imply that existing theories or models may have limited applicability. However, it was difficult to draw a clear conclusion whether or not using theory influenced intervention effectiveness. Possible reasons for the lack of theory may include the investigator not citing the theory, researchers' lack of knowledge of the theories, struggling to define appropriate theories, poorly operationalized theories, an absence of good evaluation methods and usability testing, and theories containing overlapping constructs and inconsistent use of terminology. For example, the construct of self-efficacy can be found in Social Cognitive Theory, Protection Motivation Theory, the Theory of Planned Behavior, the Health Belief Model, and Self-Regulation Theory. In addition, the simplicity of the interventions could be another reason for not including behavior theories. For example, reminding patients to take their treatment through text message appears simple and consistent with the "cue to action" constituent of many health behavior theories or models, but these theories were not always described. Our

findings of the lack of association between use of theory and outcomes was based on the theory description within each published article and should be interpreted cautiously.

Association Between Methods to Measure Health Outcomes and the Impact of These Technologies

Overall, slightly more than half of the reviewed articles had a positive impact when assessed with patient questionnaires, patient self-reports, pill counts, rates of prescription refills, assessment of patients' clinical response, and electronic medication monitors. Even though the way to measure health outcomes is an important factor in determining the impact of technology, the review failed to detect any relationship between methods used to measure health outcomes and the impact of technology. Therefore, further study is needed to replicate our results, because for each approach, there are different assumptions related to what data to collect, how to collect that data, and how to make decisions about success. Indirect methods may overestimate patient adherence. For instance, metformin treatment adherence can be monitored either by recording the number of times the medication bottle was opened, or alternately, adherence could be gauged by metformin plasma levels. Both health behaviors are part of the same behavioral class to control blood sugar levels. However, measuring metformin in blood is more effective at measuring adherence than recording the time when the bottle is opened because patients may open and close the bottle without taking any medication.

Limitations

Our review included some limitations. First, due to the heterogeneity of the research studies and the fact that some data were not available for certain types of interventions and their characteristics, some statistical tests could not be performed, hindering optimal quantitative assessment. Second, we excluded studies not written in English; this criterion might have omitted certain relevant research. Third, the majority of studies were performed in the United States, which limits generalizability of findings. Finally, because of possible publication bias toward positive findings, our review may overestimate the actual impact of these technologies.

Implications

The results from this review reveal several practical applications worthy of future study (summarized in Table 9).

Table 9. Implications of study.

Suggestion	Implications
Information technology platforms	It would be valuable to further evaluate IT platform-based interventions to form a more coherent picture of their effectiveness in encouraging patient engagement for the purpose of enhancing lasting health behavior change. A study with a long time frame may be useful to draw a clear conclusion on the effectiveness of these technologies and to determine the best ways to guarantee positive long-term effects in patients.
	Also, due to low availability of studies meeting our criteria, we could not provide or conclude relationships between factors. Therefore, we recommend doing another review when there are more studies available in future.
	In future, we can increase the quality of the review by limiting sample size and study time frame.
	IT platform interventions reviewed in this study are mutually inclusive; they use different labels and contexts to describe the same concepts and lack of formal definitions. Therefore, a common framework for analyzing these concepts is needed. A framework with an ontological approach may serve this purpose.
Patient engagements	The outreach and engagement period prior to the intervention enrollment are critical to the success of any intervention. Therefore, studies should consider that when implementing the interventions
	A study assessing determinant of patient engagement is highly recommended.
Usability	Assessment of user satisfaction toward IT platforms and their usability of these platforms are needed, and could be done through qualitative evaluations of user opinions of the respective IT platform(s).
Theories of health behavior	The literature also needs to focus more on referencing, selecting, and implementing behavioral theory to achieve the best possible impact. Reporting accurate information about interventions is essential to assessing the effectiveness of these interventions and facilitating their successful implementation.
	Also, new theories are needed to better understand how patients can participate and facilitate health behavior change, theories building on past conceptual and focus only on one aspect, a triangulation model would provide internally logical and comprehensible perception to achieve these goals.
Methods measure health outcomes	It would be valuable to further examine how different types of measurement could affect patient outcomes reported in the study. A comparison between direct and indirect methods could be helpful to draw a clear conclusion.

Conclusions

Based on our review, there is moderately strong evidence that IT platforms can engage patients in health care and improve health outcomes. The usefulness and acceptability of IT platforms can have great power in engagement and outcomes. Studies grounded in behavior theory appeared to show a positive impact on patient health behavior. To exploit the full potential of IT platforms in health care, new theories may be needed to better understand how patients can participate and facilitate health behavior change. Selecting appropriate ways to measure health behavior change and developing a common framework to analyze and understand the different components of IT platforms and their safety, effectiveness, efficiency, and acceptability will also be of great importance.

Conflicts of Interest

None declared.

Multimedia Appendix 1

Quality Assessment of Included Articles.

[PDF File (Adobe PDF File), 137KB - medinform_v4i1e1_app1.pdf]

Multimedia Appendix 2

List of the included articles and their characteristics.

[PDF File (Adobe PDF File), 233KB - medinform_v4i1e1_app2.pdf]

Multimedia Appendix 3

A glossary of terms.

[PDF File (Adobe PDF File), 107KB - medinform_v4i1e1_app3.pdf]

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Abbreviations

IT: information technology
SMS: short message service
SOC: stage of change
TPB: theory of planned behavior
TTM: transtheoretical model

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